ORDNANCE SURVEY

A BRIEF DESCRIPTION OF THE NATIONAL GRID AND REFERENCE SYSTEM

Ordnance Survey Booklet No. 1/45

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1946
FOURPENCE NET

THE NATIONAL GRID
AND
SYSTEM OF REFERENCE

The basis of the original surveys.

The original Principal Triangulation of Great Britain, carried out in the first part of the nineteenth century, was the foundation on which the pre-war surveys of this country were built. Upon this foundation secondary and tertiary systems of triangulation were raised. The tertiary triangulation covered the entire country with a network of triangles having sides about one mile long, and it furnished a framework to which the large scale detail surveys were tied. Though it rested upon and was attached to the Principal Triangulation, it was not adjusted to fit it exactly. The tertiary triangulation was adjusted and the large scale surveys were plotted county by county, or by separate groups of counties, without any direct reference to triangulation and survey of adjacent counties; for there had been no opportunity and no apparent or pressing need, at the commencement of the survey, to pursue any other course.

Flat representation of curved surfaces.

Now it is well known that, when objects surveyed and measured on the curved surface of the globe are plotted on the flat surface of a piece of paper, it is not possible to draw those objects on the flat representation in their true relative positions. Some conventional method must be used for converting the measurements made on the curved surface of the globe to those required on the flat piece of paper. The method is known as a projection.

What is required of a projection.

When the area to be represented is small the plane surface nearly fits the curved surface, and in consequence any projection can be conveniently employed. As the area to be represented increases in size the divergence of the plane from the curved surface also increases. One is then compelled to select a projection well suited to the purpose in hand. Different

projections preserve different geometric properties, for no one projection can preserve all geometric properties simultaneously. It is therefore desirable to select that projection which will best preserve the geometric properties most needed. It is now usually recognised that the geometric property most needed in large scale survey is orthomorphism. This property ensures that the correct shape of any small area is preserved, or, to put it another way, that within any small area the scale is sensibly the same in all directions — although the scale may vary throughout the projection as a whole. This property of orthomorphism enables one to survey limited areas by simple methods without making any corrections to the angular measurements or needing to apply any more than a simple arithmetical scale factor to the linear measurements.

When the tertiary triangulation was computed, the computations were made in rectangular co-ordinates on the Cassini projection, which is not orthomorphic; furthermore each county, or group of counties, was computed on a separate Cassini projection based on a separate county origin. The Cassini projection is quite suitable for areas of limited size such as the counties of Great Britain, but when extended to cover the whole of Great Britain in one span, it introduces angular distortions that become intolerable for large scale surveys.

A single national system recommended.

When the survey at the 1/2500 scale was begun it had been intended to make a separate series of plans on a separate Cassini projection for each county. The inconvenience of a break in continuity between the counties had been accepted, but as the survey progressed, the extent and practical reality of this inconvenience became more apparent. Those counties that had not yet been surveyed were accordingly formed into groups, each group on a single projection, and some grouping was contrived also for those counties that had already been surveyed. The Large Scale Plans, therefore, which are sometimes described as the map of Great Britain, form in fact separate maps of the counties of Great Britain. Attempts to survey across from one county map to the next have always been attended by difficulties. On the small scale maps also there was a break in continuity between England and Scotland, the two countries having been plotted on different projections. To enable all maps and plans of Great Britain to be on one projection and to eliminate discontinuities the Davidson Committee* recommended that the

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* A Committee set up in 1935 under the chairmanship of the Right Honourable the Viscount Davidson, G.C.V.O., C.H., C.B., to consider Ordnance Survey maps and plans. Their interim report (1936) and final report (1938) were published by H.M.S.O.

1/2500 survey should be recast on national instead of county sheet lines on a national projection.

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The basis of the new work.

The existence of the new Primary Triangulation, which was in course of production at that time and was completed as far north as the Caledonian Canal just prior to the outbreak of war, made it easier than otherwise to put the Committee's recommendation into effect. The old Principal Triangulation no longer fully met the needs of the Survey and some of its stations had disappeared altogether. It did, however, give orientation and a check on overall scale to the new Primary Triangulation, and some of its stations were included in the new work. On this new foundation the new secondary framework is raised, and adjusted securely to it block by block as each is built; and (to continue the building metaphor, which to be appropriate must suppose a single storied steel-frame structure on a monolithic foundation) to this secondary framework the tertiary framework is tied room by room. Finally the detail surveys are fixed in place brick by brick. Thus the framework for any single room can be completed, the bricks put in place, and the room occupied quite independently of neighbouring rooms, but with the absolute certainty that, whensoever it may be built, it will fit exactly into place without any disturbance whatever to the neighbouring rooms or their occupants. This gives us complete consistency throughout Great Britain and freedom of action to build where we must and when we must.

The National Projection.

The Committee's recommendation, however, compels the use of a projection that will not introduce unacceptable distortions, on any of the scales, when it is extended over an area the size of Great Britain. The computation of such a projection had been begun by the Ordnance Survey in 1924 with this ultimate object in view, and it was already in use for the new One Inch map. It is an orthomorphic projection known as the Transverse Mercator. Its origin is "Long. 2°W., Lat. 49°N." Accordingly this projection has now been adopted as the national projection for general use with all the new maps and plans of Great Britain.

In its simplest form this projection has the property of representing its central meridian as a straight line that is true to scale; to the east and west of the central meridian the scale gradually increases. This simple form is slightly modified to

make it more suitable for use with the maps and plans of Great Britain. In order to reduce the size of the scale error at the east and west extremities of the country the scale at the central meridian is arbitrarily reduced by the factor 2499/2500. This has the effect of making the scale 0·04% too small at the central meridian and 0·04% too large near the east and west coasts, while at about 180 Kms on either side of the central meridian the scale is true. Variations from true scale that are as small as these have no visible effect upon the representation of topography at the 1/1250 scale.

When rectangular co-ordinates are referred to the origin at 2°west 49°north, the easting co-ordinates of points lying west of the central meridian are negative; and the northing co-ordinates, though all positive, are so large for points in the north of Scotland that some in the very north exceed 1000 Kms. In order to avoid these inconveniences 400 Kms have been added to all easting co-ordinates and 100 Kms subtracted from all northing co-ordinates. This places the working position of the origin a little to the south-west of Lands End and ensures that the co-ordinates of all points on the mainland of Great Britain are positive and less than 1000 Kms.

It is, however, impossible to arrange for all the islands, as well as the mainland, to fall in the same 1000 Kms square. The Shetlands, Foula, Fair Isle and the northern part of the Orkneys fall in the next square to the north; and consequently have co-ordinates which are a repetition of those falling in Southern England. To make these far northern co-ordinates unique, the letter N is prefixed where the northing value is 1000 Kms or more (*e.g.* Lerwick N41/4841).

The National Grid and the unit of measure.

The Davidson Committee also recommended that a National Grid should be super-imposed on all large scale plans; and on smaller scale maps (with certain exceptions), to provide one reference system for the maps of the whole country. It further recommended the adoption of the international metre as the unit on which the grid should be based.

A grid is just a series of lines drawn parallel and at right angles to the central meridian of the projection, thus forming a series of squares. These lines are the construction lines that enable the details of topography to be plotted on the projection. The selection and spacing of the particular construction lines to be shown on the published maps is a matter of convenience.

The basic unit used for calculating the grid is of very little consequence to those giving grid references. For that particular purpose the interval between the grid lines need not necessarily bear more than an arbitrary relation to it. But

since our system of counting is decimal, the grid lines must be so arranged that decimal subdivisions of the grid are immediately apparent. Moreover, if these subdivisions are to contain complete decimal multiples of the basic unit, then the basic unit itself must be of a length that is convenient for use on the various scales of the national maps and plans. For this reason, amongst a variety of others, the Davidson Committee recommended the use of the international metre. It is interesting to note that the use of the yard has introduced such curious hybrids as the Kiloyard, while the mile finds such unfamiliar subdivisions as the Decimile and the Centimile. The basic unit, however, has no more significance for the simple user of references (as opposed to surveying co-ordinates) than the units in which we measure motor tyres or graduate the dials of wireless sets have for the ordinary users of those now familiar and everyday articles; for who, buying, say, a 525 × 16 motor tyre or tuning to the 25 metre waveband, is much concerned about what unit he has used in expressing his needs, so long as he gets what he wants. It is so with the National Grid.

The choice of the particular grid lines of the National Grid to be shown on the maps and plans depends upon the scale of the map or plan. Thus on the Ten Mile and Quarter-Inch maps the lines are shown at intervals of 10 Kms; on the One Inch, 1/25,000 and Six Inch maps at intervals of 1 Km; and on the 1/2,500 and 1/1,250 scale plans at intervals of 100 metres. These grid lines enable one to obtain the co-ordinates of any point on the map with an accuracy appropriate to the scale of the map; for instance, on the One Inch map, on which the grid lines are 1 Km apart, the co-ordinates can be estimated to within 100 metres.

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Methods of grid reference.

The grid alone, unaccompanied by any explanation, is sufficient to enable anyone to devise references and indexes to suit his own private purposes. But it is advisable also to set forth some systematic and consistent method of numbering the grid lines and of writing the co-ordinates obtained from them, so that those that wish may use it. This provides a simple system ready to hand for those wishing to collaborate with one another in the use of grid references; for clearly collaborators must all use one and the same system It also provides a system that is nation-wide and likely to be employed by others. It is, of course, open to anyone who finds such a national system unsuited to his own purpose, particularly to some very specialised purpose of limited publicity and circulation, to devise his own system, for the grid is intended to be a servant

and not a master; but before so doing he will naturally weigh the disadvantages, as well as the advantages, of departing from a system that is well known and likely to be widely used with the corresponding advantages and disadvantages of the opposite course.

The designers of the national system appreciated that any system to be satisfactory must be :—

i. Universal for the whole of Great Britain.
ii. Easy to use and not cumbersome.
iii. Quite definite and unambiguous in its meaning.
iv. Applicable to all scales.
v. Sufficiently precise for use on the largest scale Ordnance Survey plans.

The system adopted.

Any single system that is applicable to all the scales becomes rather cumbersome when used unmodified for the largest scales. The system now adopted, however, is such that it can be written in as brief a form for large scale plans as for small scale maps. The method of abbreviating the reference on the large scale plans varies slightly, as will be seen, from that used for the small scale maps, and this variation gives the appearance of introducing two separate systems, one for the large scale plans and another for the small scale maps. In reality there is one system with two different conventions for writing the abbreviations of it. When full references are given by either method the one can be transcribed into the other at sight, both having been derived from the same unique grid. This preserves, for use when necessary, the uniqueness throughout Great Britain of a full reference in the national system given on any scale on any map or plan that carries the National Grid.

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Grid references on the maps.

In the system as applied to small and medium scale maps, that is to maps on the Six Inch and smaller scales, the general method of giving a grid reference is described below. The point chosen for the example (see Diagram I) is in London, and can be found on Sheet 12 of the Quarter Inch 4th Edition (with National Grid) and on Sheet 171 of the One Inch 6th Edition.

The co-ordinates of the point to the nearest metre are:– E538932 N177061

By adopting the convention of writing the Easting always before the Northing we may drop the letters E and N, thus:– 538932 177061

For most purposes it is sufficient to know a position to the nearest 100 metres, so we may drop the last two figures of each ordinate representing the digits and tens of metres, thus:– . . 5389 1770

The general location of a point is usually known to within a 100 Kms, so we may drop the first figure of each ordinate representing the hundreds of kilometres, thus:– 389 770

The six figures now remaining, 389 770, form what is known as the *Normal National Grid Reference*. These figures are shown in large type in Diagram I.

How the grid lines are numbered. (see Diagram III)

Now in order to read grid references on the various maps it is necessary to notice which grid lines are shown on the maps and how they are numbered. On the Ten Mile and Quarter Inch maps the grid lines are spaced at intervals of 10 Kms; single figures are shown in the margins against each grid line and denote the tens of Kms in the ordinate of that grid line. On the One Inch, 1/25,000 and Six Inch maps the grid lines are spaced at intervals of 1 Km; two figures are shown in the margins against each grid line and denote respectively the tens and the digits of Kms in the ordinate of that grid line. These marginal figures enable each grid line to be readily identified and the grid references to be quickly given. By way of example, in order to give from a One Inch map the grid reference of the point in London referred to in our example above, first read the large figures printed in the margin of the map opposite the north-south grid line bounding the western edge of the square in which the point lies. These figures, 38, are respectively the tens and the digits of Kms in the Easting of that grid line, and they form the first two figures of the *Normal National Grid Reference*. Next estimate within the square how many tenths of a square the point lies away from that grid line towards the next. The number of tenths, 9, completes the Easting of the point to the nearest 100 metres, and is the third figure of the reference. A similar process, but using the set of grid lines at right angles to those already used, gives the last three figures of the references, 770. The complete reference is then 389 770.

Unique references.

It will be observed that this reference is not unique throughout Great Britain but recurs regularly at intervals of 100 Kms in all directions. To make it unique we must insert again the figures representing the hundreds of Kms in each ordinate. We insert these figures in front of the *Normal National Grid Reference*, separating them from it by an oblique stroke, thus: 51/389770. This makes the reference unique throughout Great Britain, and in this form it is known as the *Full National Grid Reference*.

This device of making, for the sake of brevity, the *Normal National Grid Reference* unique only within the limits of each 100 Km square, and of rendering it at choice unique throughout Great Britain by prefixing figures representing the co-ordinates of the south-west corner of the particular 100 Km square, is equivalent to dividing Great Britain for referencing purposes into 100 Km squares. These squares are shown at Diagram II. A diagram like this is printed in the margin or in the cover of the small and medium scale maps. In this diagram the figures appearing inside each 100 Km square are the co-ordinates in hundreds of Kms of the south-west corner of that square. They provide numbers, one in each square, which may conveniently be used to define without ambiguity the squares themselves, and for the *Full National Grid Reference* of any point within, are the numbers which precede the oblique stroke.

References to the nearest kilometre.

On some occasions the location of a point may need to be defined only to the nearest 1 Km. The figures representing the hundreds of metres can then be dropped, thus: 3877. In this way one may give a shorter form of reference known as the *Normal Kilometre Reference* (often called the "Four Figure" reference). However, there may then quite well be possibility of confusion with other points that have the same normal reference lying 100 Kms away; consequently the *Full Kilometre Reference*, 51/3877 (often called the "Full Four Figure" reference), will then be more usual. Such *Full Kilometre References* may be needed quite frequently on the Ten Mile and Quarter Inch maps. On these maps, as already explained, the grid lines are numbered in the margin with single figures; these figures are printed in large type; in addition, at each 100 Km grid line, figures in small type are printed and prefixed to those in large type; these figures in small type denote the hundreds of Kms in the ordinate of that grid line, and indicate also the incidence of the 100 Km squares upon the map. This incidence of the 100 Km squares can equally well be found from the diagram of grid incidence (see Diagrams II & III). On the Ten Mile and Quarter

Inch maps a *Normal Kilometre Reference* can be given by reading the figures in large type in the margin, 3 and 7 in our example, and estimating the tenths, 8 and 7, within the 10 Km square, thus: 3877. The *Full Kilometre Reference* can be completed by prefixing the figures 51 of the 100 Km square, to be found either from the figures in small type in the margin or from the diagram of grid incidence, thus: 51/3877.

Full Kilometre References can equally well be given on the One Inch, 1/25,000 and Six Inch maps, but are less often needed at those scales. On these maps the small figures denoting the hundreds of kilometres in the ordinate of the grid lines are prefixed to the larger figures in the margin at convenient intervals. The diagram of grid incidence is printed in the margin or in the cover of these maps also.

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Grid references on the plans. (see Diagram IV)

In the system of reference as applied to the large scale plans, the method of abbreviating the full reference is slightly different from that used with the small and medium scale maps. The 1/2500 scale plans are published in sheets one kilometre square bounded by Km grid lines of the National Grid. Each plan is numbered by the *Full Kilometre Reference* of its south-west corner; thus, to continue our example, the 1/2500 scale plan containing our point is plan No. 51/3877. It will be observed that each plan number itself defines uniquely to the nearest kilometre the position of any point lying in it. The 1/1250 scale plans are published in sheets 500 metres square; each forms one quarter of a 1/2500 scale plan; each is numbered by the 1/2500 plan number suffixed by NW, NE, SW or SE to show in which quarter of the plan it lies; thus, again to continue our example, the 1/1250 scale plan containing our point is plan No. 51/3877 SE.

It will also be noticed in passing that this system of numbering the national plans makes every map that carries the National Grid automatically useful as an index diagram to the sheets of the national plans, except for a few coastal sheets which are oversize, or contain insets.

Precise definition of position needed.

Grid references on the large scale plans usually need to indicate position rather precisely, often to the nearest 10 metres and sometimes to the nearest single metre. Were we to use the full reference on every such occasion we should have a very cumbrous figure, 51/38932770б1 in our example, altogether too

cumbrous for ordinary use. But with so precise a definition of position, confusion with other points lying one kilometre distant seldom troubles us. In consequence we can and usually do confine the references on large scale plans to a definition of position that is unique only within the compass of a particular square kilometre. It must be remembered that the system of numbering all the large scale plans (1/2500 and 1/1250) defines uniquely which particular square kilometre; so that whenever, in particular circumstances, there is real likelihood of confusion with some other point on a neighbouring plan, the particular 1/2500 plan number can always be added to the reference, thus making it unique throughout Great Britain.

Method of reference.

The grid lines on the large scale plans are drawn at intervals of 100 metres, thus dividing the plan into squares 100 metres wide. Each grid line is numbered in the margin of the plan with the figure denoting the hundreds of metres in the ordinate of that grid line. To give a reference we read the figure printed in the margin opposite the north-south grid line bounding the western edge of the 100 metre square containing the point—9 in our example; then we estimate, within the 100 metre square, how many tenths of a square the point lies away from that grid line towards the next grid line—3 in our example: if a more precis definition of position is needed, then the actual distance from the grid line is measured on the plan with a scale in metres—32 metres in our example. This completes the first half of the reference, which is 93 to the nearest 10 metres and 932 to the nearest metre. A similar process, but using the set of grid lines at right angles to those already used, gives the second half of the references. The complete reference is then 9306 to the nearest 10 metres and 932061 to the nearest metre. When the full reference is needed the number of the plan itself must be prefixed, thus 51/3877/932061, and this is known as the "Full One Metre Reference."

Although precision of reference is an essential requisite of large scale plans, it is often necessary and convenient to be able to give a general indication of the position of some feature in the briefest possible form. This is done by writing only the single figures appropriate to the grid lines bounding, on the west and south, the square in which the feature lies. In our example this short reference is 90. It is known as the *Hundred Metre Reference*, and is often called the "Square Reference" because it simply indicates, in the briefest form and without further elaboration, the square in which the feature can be found.

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Comparative table.

We may now tabulate the various forms of grid reference employed on small and medium scale maps and on large scale plans. This tabulation (see below) uses the same one point that has been common to all our examples. Its full co-ordinates are East 538932 metres, North 177061 metres.

Table Showing the Various Kinds of Grid Reference on the National Grid

Full co-ordinates of the point used as example:
E 538932 m. N 177061 m.

Precision of references is to the nearest:–	Name of Reference	Reference
	On Small and Medium Scale Maps	
100 Metres	Normal National Grid Reference	389 770
100 Metres	Full National Grid Reference	51/389 770
1 Km	Normal Kilometre Reference	38 77
1 Km	Full Kilometre Reference (and therefore the Plan Number of the Large Scale Plan containing our point).	51/38 77
	On Large Scale Plans	
100 Metres	Hundred Metre Reference	9 0
10 Metres	Ten Metre Reference	93 06
1 Metre	One Metre Reference	932 061
100 Metres	Full Hundred Metre Reference	51/3877/9 0
10 Metres	Full Ten Metre Reference	51/3877/93 06
1 Metre	Full One Metre Reference	51/3877/932 061

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Point used in examples: P

Diagram I.

Incidence of the Grid on Great Britain

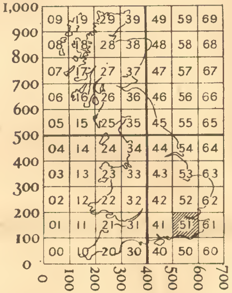
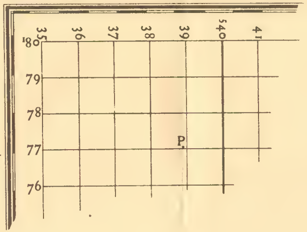
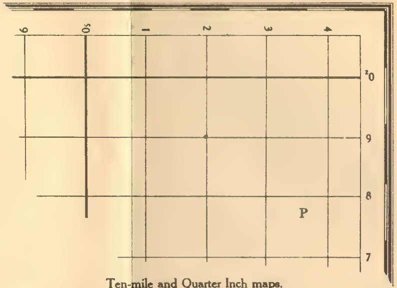


Diagram II.

Diagrams showing the spacing and the numbering of the grid lines on various maps



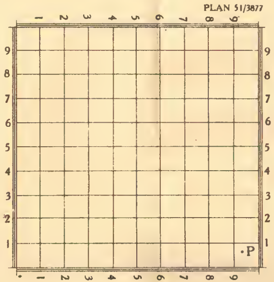
One Inch, 1:25,000 and Six Inch maps.



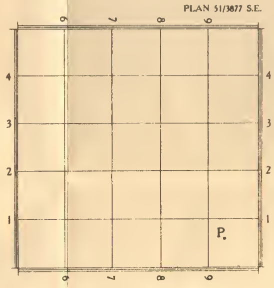
Ten-mile and Quarter Inch maps.

Diagram III

Diagrams showing the spacing and the numbering of the grid lines on large scale plans



1: 2500 scale plans



1: 1250 scale plans

Diagram IV

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